PLANT OPERATION AND CONTROL
OF
NORTH AMERICAN CEMENT CORPORATION
OF
SECURITY, MARYLAND

CONTENTS

Submitted by:

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to:

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PLANT OPERATION AND CONTROL OF NORTH AMERICAN CEMENT CORPORATION OF SECURITY, MARYLAND

I SUMMARY

The Security, Maryland plant of the North American Cement Corporation is situated near a large limestone quarry which has been divided into sections according to the chemical analysis of the rock in each section. As the rock is needed it is dynamited, loa ded into rail cars and hauled to a crushing house on the edge of the quarry. Here it is crushed to about one inch or less and stored in a certain bin according to the composition of the rock. If the rock is wa nted for commercial purposes it is stored in separate bins accordi ng to size. When the plant receives an order for cement of definite composition, the laboratory directs from which bins to remove the rock. This is done by automa tic hoppers. The mixed rock is carried to storage in the main plant by freight cars. As needed, it is conveyed to one of two rotary dryers. It is then stored again. At the same time crushed shale is dried in another rotary dryer and stored. As the laboratory directs the rock and shale are mixed a nd pulverized to the FINENESS consistency of flour. This flour is then stored in one of twelve control tanks according to the composition of the flour. As the flour is needed it is carried from one or more of the control tanks to a mixing tank where it is mixed to give the proper blend. The blend is elevated to a kiln tank and conveyed to a rotary kiln. The kiln is heated by burning

pulverized coal at the opposite end to the feed. The fused clinkers are discha rged at the hot end and carried to storage where they are quenched with a water spray. As the hot gases leave the cool end of the kiln they pass through boilers, the steam from which runs the power plant. The cooled gases then are cleaned by passing them through multiclones and Cottrell electric precipitators. The dust thus collected is lime and potash and is sold as such for agricultural purposes. In the meantime, the clinker, having been analyzed, is carried from storage and mixed with a prescribed amount of gypsum. This mixture is repulverized and the oversize particles separated from the correct-sized particles in an air separator. The rejects are repulverized. The cement is pumped to storage. Often it must remain sealed in storage for 10 to 28 days in order to compete for government or private contracts. The cement is then conveyed to filling tanks from which sacks and barrels are filled.

There are two control la boratories. One, the chemical laboratory analyzes all samples of crude, raw, and finished products periodically for chemical composition. The other, the physical laboratory analyzes all samples of raw, coal, clinker, and finished product for fineness, soundness, tensile strength, compression strength, time of set, and expansion.

The process used at Security is the economical dry process, so called because no moisture is added to the mix as in the wet process. The Security plant operates very efficiently and safely and is very proud of its safety records.

II QUARRY OPERATIONS

The quarry consists of two levels with faces about 50 feet in height. Holes are drilled 25 feet back from the face and 15 feet apart. These holes are 6 inches in diameter and 55 to 60 feet deep. Samples are drawn up and sent to the chemical laboratory, where they are subjected to a complete analysis consisting of analyses for silica, lime, magnesia, and iron. In this fashion, the analysis of each section of the quarry is known and from this data can be determined the location from which to take rock in order to meet contract specifications. There is, at Security, one section that has remained untouched because the rock in that area contains an excess of magnesia. The magnesia over 5% is harmful because it causes disintegration of the cement by hydrating from MgO to $Mg(OH)_2$.[1]

As the laboratory gets the contract specifications, it orders the blasting of a certain section or sections of the quarry. The rock is then loaded into rail cars and is taken to a dumping platform where it is dumped into a receptacle adjoining a jaw crusher. As the jaw crusher empties one charge, another charge is fed into it from the receptacle. In the crusher, the rocks are reduced to about nine inch sizes. A belt conveyor carries the crushed rocks up an incline to a hammer mill crusher to be reduced to about one inch or finer. The reduced rock is carried on a belt conveyor to a storage house. The storage house is divided into a series of bins, each bin containing reduced rock from a definite section of the quarry. The rock leaving the hammer mill is deposited in the bin containing rock of its composition.

Quarry, showing the two levels and a drill in operation in the background

Dumping the cement rock at the crusher house.

If the rock is to be used for commercial purposes such as road building, it is quarried from a section of the quarry containing almost pure limestone. It goes through the same operations as the cement rock until it leaves the jaw crusher. From the jaw crusher this rock is carried by a belt conveyor to a gyratory crusher, then is sorted into sizes on a hummer screen. This rock is then stored with respect to sizes.

At the bottom of each bin there is a hopper feeding onto a belt conveyor. As the laboratory directs different bins may be fed onto the conveyor to give a mixture of cement rock of desired composition. This mixing takes place on the conveyor and is automatically controlled by an oscillating bar to which the hoppers of the designated bins are attached. The mixture is carried to a bucket elevator on which it is elevated and dumped into a freight car to be carried to the main plant. This operation is carried on at night.

Statistically about 1500 tons of stone are handled in a ten-hour day. The Crushers have a capacity of 200 tons/hr. The storage building has a capacity of 14,000 tons.

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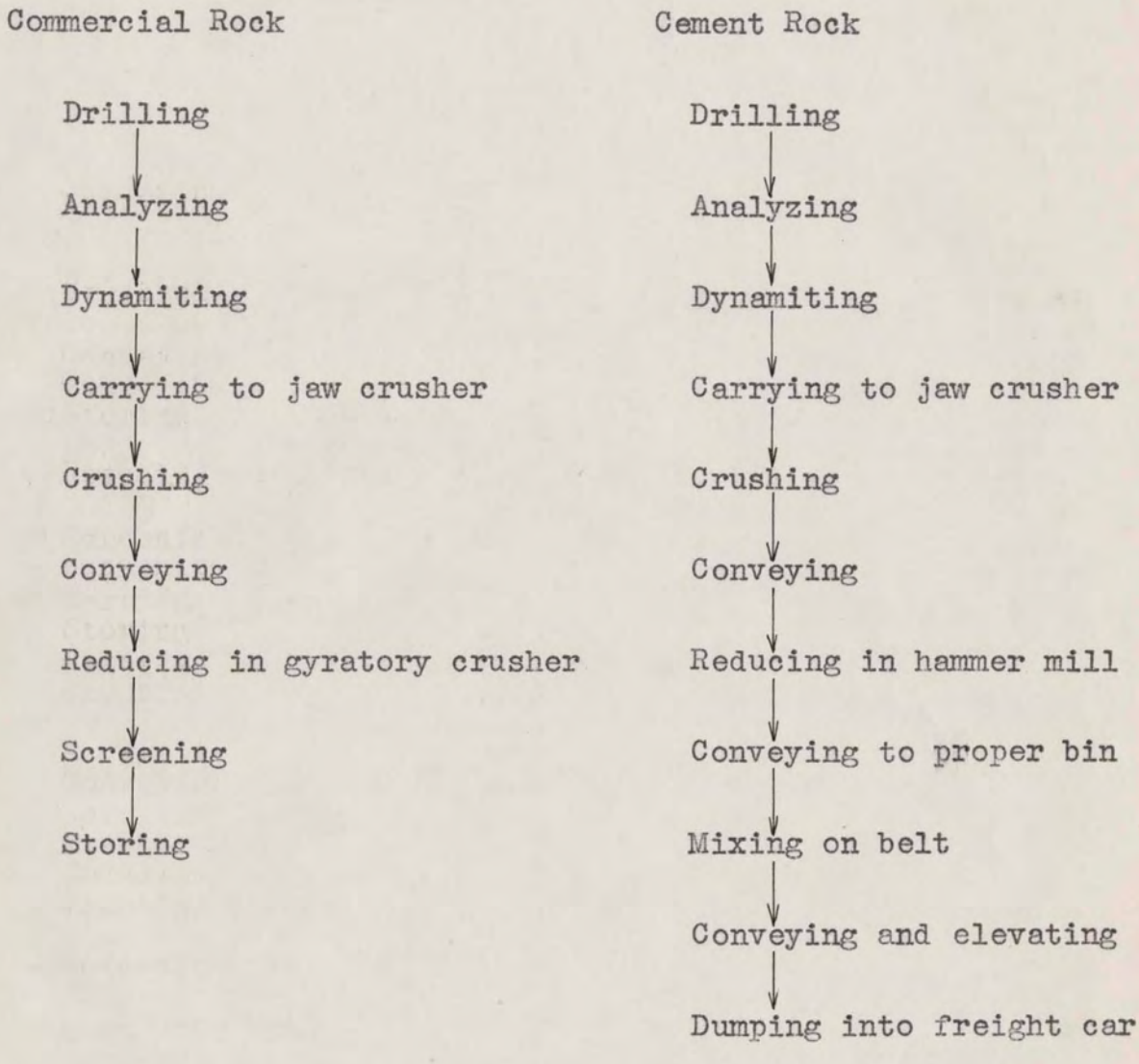
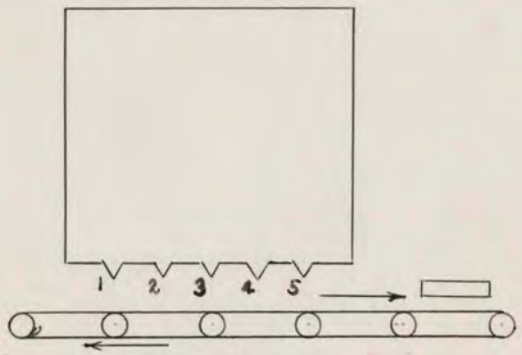
(1). Leighou, Chemistry of Engineering Materials

Flow Sheet


Commercial Rock
Drilling
Analyzing
Dynamiting
Carrying to jaw crusher
Crushing
Conveying
Reducing in gyratory crusher
Screening
Storing
Cement Rock
Drilling
Analyzing
Dynamiting
Carrying to jaw crusher
Crushing
Conveying
Reducing in hammer mill
Conveying to proper bin
Mixing on belt
Conveying and elevating
Dumping into freight car

III MAKING THE FEED

The freight cars with the cement rock are taken to the main plant. There the rock is dumped into underground bins from which a bucket elevator takes the rock to stone tanks for storage. A stone tank has five hoppers beneath it in this fashion:

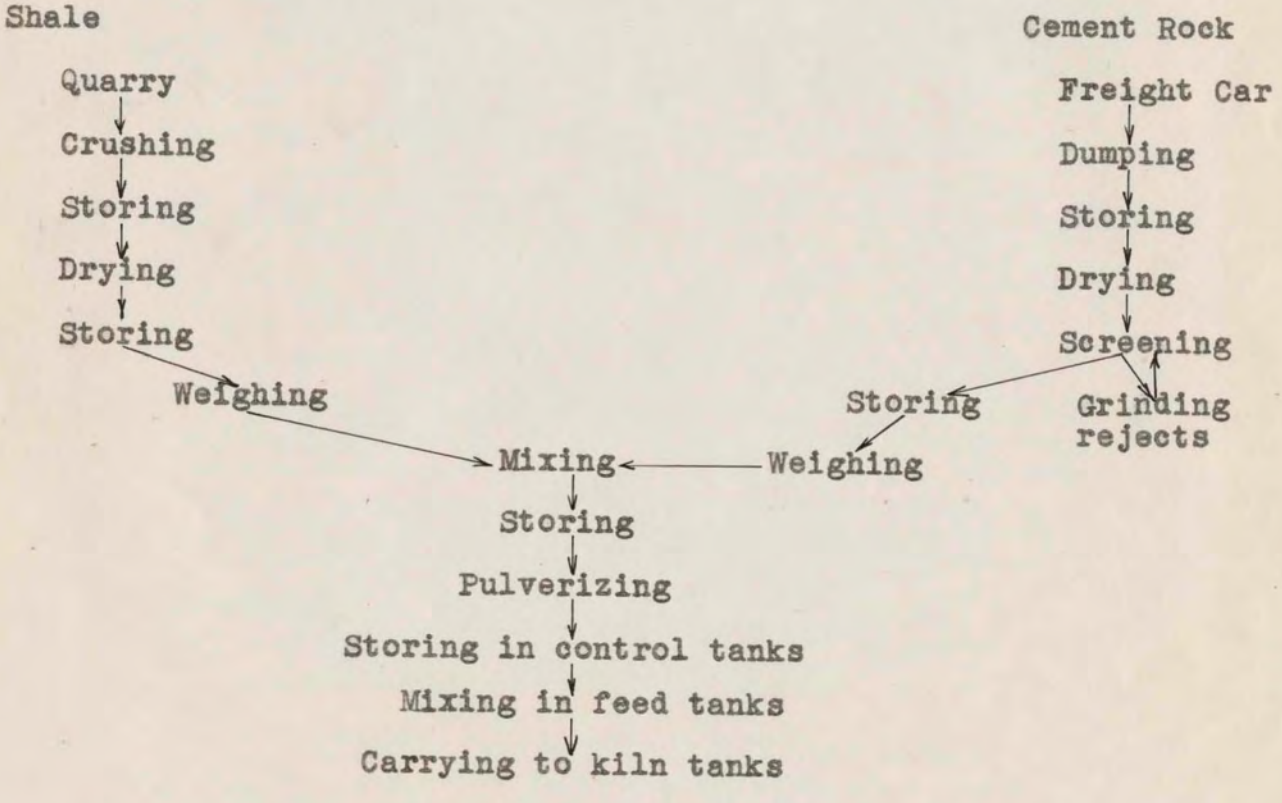


The use of the five hoppers increases the useful area inside the tank and allows a more uniform feed onto the belt conveyor beneath the hoppers. The hoppers are so controlled that, refering to the diagram, feed from hopper "2" will fall on feed from hopper "1"; feed from hopper "3" will fall on feed from hoppers "1" and "2" and so on down the line. This gives uniform distribution of rock. After the belt conveyor passes out from under hopper "5" it passes under a strong electromagnet which removes extraneous metal. The rock is then deposited on a bucket elevator and distributed to one of two rotary driers. These driers are 5½ feet in diameter, 50 feet long and are slanted down toward the hot end. The driers are heated by burning pulverized coal and blowing air over the coal into the drier, countercurrent to the flow of the rock. The operation removes most of the moisture from the rocks. The dried rocks are deposited at the hot end and carried by an elevator belt to a shute and belt, then deposited on a hummer

screen to separate the rocks of the desired sizes of ¼ inch or less. Oversize rocks are returned to a crusher, reduced, and re-screened. The rocks of the correct size are conveyed to a raw storage tank. While this drying operation is going on, shale from a quarry in Williamsport is reduced and stored in a hopper at Security. The shale contains the silica, alumina, and iron necessary to bring the cement to the desired analysis. After this shale has been reduced in size it, too, is fed into a rotary drier, dried on the countercurrent principle, and stored. From storage the dried rock is fed to belt conveyors to mixing bins. The shale is conveyed from storage to automatic scales and a weighed amount is conveyed to feed tanks to be fed into the rock. About 50 pounds of shale are added to 600 pounds of rock. The mixture of rock and shale is conveyed to a Hardinge ball mill. This mill is 10 feet in diameter, 5½ feet long and is loaded with 25 tons of steel balls from 3 inches down which pulverize the mixture as the mill revolves. Air swept through the mill carries the powder from the Hardinge mill to 14 Fuller mills where it is further pulverized to such an extent that 90% will pass a 200 mesh screen. The capacity of the mills is about 1500 tons for a 24-hour day. In the Fuller mill the stone is pulverized between a steel die and four 12 inch steel balls driven by centrifugal force around the periphery. The raw flour-like powder, as it leaves the Fuller mills is conveyed to storage in one of twelve control tanks depending on the composition of the flour. These tanks are under laboratory control. The laboratory knows by analysis what each tank holds and can, by proper blending of the contents of several control tanks, obtain

a mixture which will give a clinker within 0.2% of laboratory prediction. Upon laboratory direction, flour from several control tanks is conveyed to one of three feed tanks for mixing. The mixture is then conveyed and elevated to one of five kiln tanks each situated above the cool end of one of five kilns.

Flow Sheet



IV MAKING THE CEMENT

From the kiln tanks the feed is carried continuously on a belt conveyor to the cool end of the kiln (about 1400°F) and deposited in the kiln. There are five kilns at Security. Each is a revolving drum, 125 feet long. The diameter at the cool end is 8 feet while that at the hot end (2800°F) is 10 feet. This difference in diameters plus a slight slant towards the hot end allows the feed to drift countercurrently to the heat. The kiln is heated by burning pulverized coal which is blown in by air. The coal is pulverized and analyzed at the Security plant. The plant uses about 250 tons per day. After the feed enters the cool end of the kiln, it loses any moisture not removed in the driers. Then as the feed reaches a hotter section CO_2 is freed from the limestone and goes off with the hot gases. At the hot end, the cement clinker is formed, 2 to 2½ hours after charging. This clinker contains fused tricalcic silicate, tricalcic aluminate, and dicalcic silicate. These compounds are unstable and rearrange when wet. The tricalcic silicate forms a gelatinous calcium hydrate and silica to which is due the initial set. As the hydration continues, the gelatinous material binds the grains of sand which are added, and the stone filler, to a hard mass. The tricalcic aluminate and the dicalcic silicate are hardeners but are not as rapid as the tricalcic silicate.(2) After the clinkers are formed and reach the discharge end, they are deposited into a pit from which a bucket elevator carries them to an opening in the wall through which they are dumped into an open-air storage. As they are dumped, they are quenched with a water spray. This sudden cooling gives a protective coating to

One of five rotary kilns at Security

the clinkers.

In the meantime, the hot gases have passed out the cool end of the kiln into a boiler system of three 1000 Horsepower boilers. The gases make four passes through the system. The steam thus generated goes to drive the company's electric power plant which in turn drives all the company machinery. After the gases leave the boilers they are passed through multiclones where the suspended particles are separated and where most of the lime is collected. The gas then goes through a spray chamber in which water is sprayed over the gas to increase the ionization of the suspended particles. This increases the efficiency of the Cottrell electric precipitators through which the gases pass next. The cleaned gases are then allowed to escape to the atmosphere. The precipitators are periodically shaken down and the collected lime from the multiclones and potash from the precipitators are sold as such to fertilizer companies.

Statistics on the kilns show that 1500 tons of raw material is fed into the kilns daily with formation of 940 tons of clinker, equivalent to 5000 barrels, and 560 tons of CO_2 gas.

As the clinker is needed, it is carried by an 8-ton crane to the clinker grinding department. Before grinding, gypsum is added in an amount designated by the laboratory. The proportion is controlled by automatic scales and is generally 12 to 13 pounds gypsum for each barrel of clinker. The mixture is conveyed from the mixer to storage bins. Then, as needed, it is carried to 10 Fuller mills for pulverizing. From these mills it is elevated to tube mill tanks. From these tanks the cement is let into 5 tube

Air separator

mills each of which is charged with 15 tons of small steel balls. The action of the balls reduces the cement further. The powder is then conveyed and elevated to two air separators in which the centrifugal force of an air current separates the large particles from the small. The large particles are sent out of the separator and are carried by screw conveyors to be reground in the Fuller and tube mills from whence they are again separated. The powder which comes out of the separator is of such fineness that 96% will pass a 200 mesh screen. This fine powder is pumped by air into storage silos and 39 rectangular bins with a total capacity of 200,000 barrels. The effective capacity is sometimes cut down by contractors who require that the new cement remain in storage for 10 or 28 days before it is allowed to be used in contract bids. As the cement is required, it is withdrawn from storage and conveyed to the fillers from which cloth and paper bags, or barrels are filled, and then shipped to consumers as North American Portland Cement. One bag contains 94 pounds of cement while one barrel contains 376 pounds. The cloth bags are reclaimed, cleaned, and patched when torn. Bags too badly worn are discarded.

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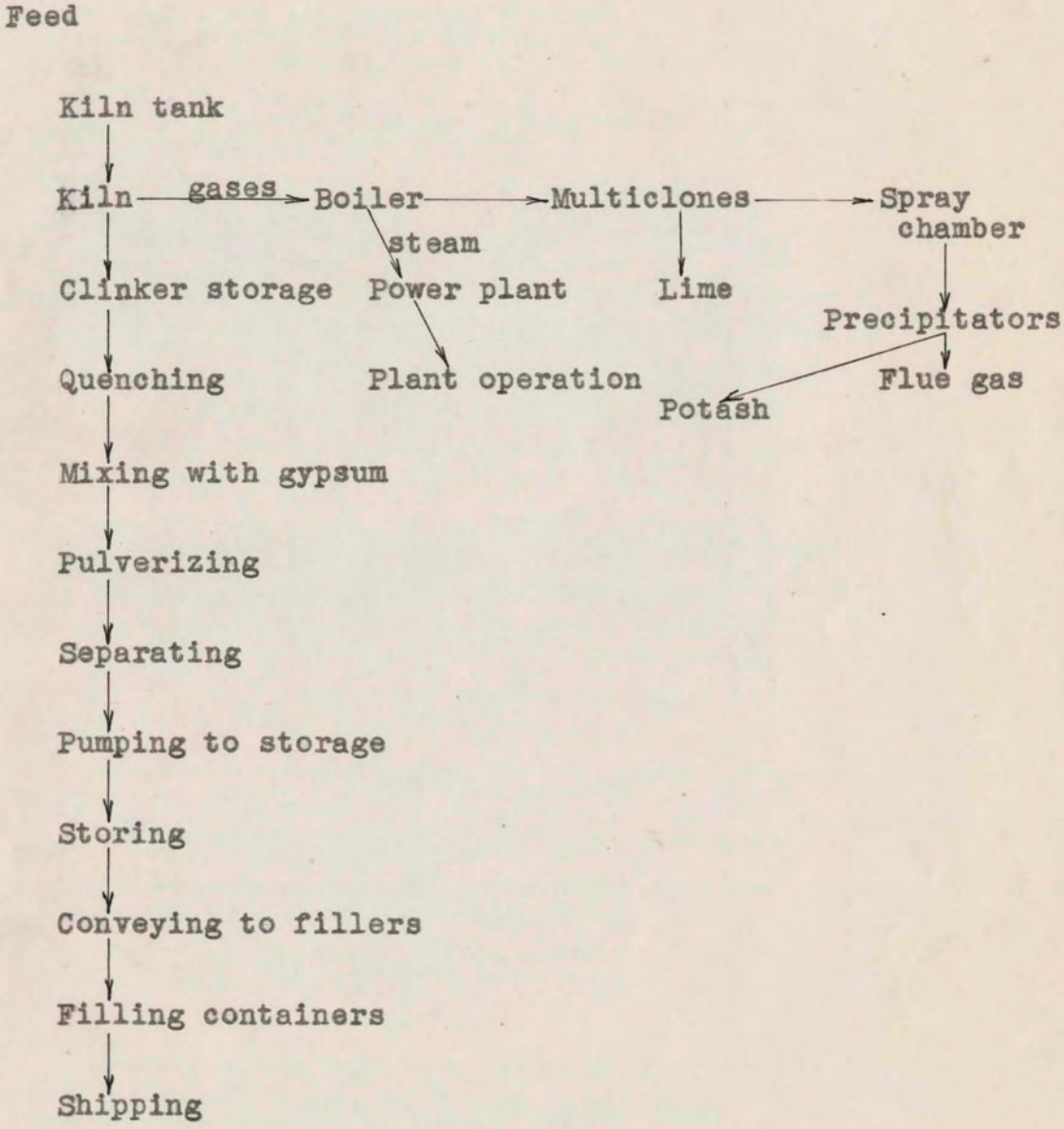
(2). Reigel, Industrial Chemistry

Flow Sheet


Feed
Kiln tank
Kiln
gases
Boiler
Multiclones
Spray chamber
steam
Clinker storage
Power plant
Lime
Precipitators
Quenching
Plant operation
Flue gas
Potash
Mixing with gypsum
Pulverizing
Separating
Pumping to storage
Storing
Conveying to fillers
Filling containers
Shipping

V CONTROL OPERATIONS

The control and testing is carried on in two laboratories, the chemical laboratory and the physical laboratory. All tests are standard according to the American Society for Testing Materials and the Cement Reference Laboratory.

The Chemical Laboratory runs all chemical analyses. It receives samples from the quarry and runs complete analyses for lime, silica, magnesia, and iron. Tests are run for lime on the cement rock in the stone tank. The shale is tested for iron, alumina, and silica. The blend is analyzed for lime before entering the kiln. Samples are drawn from the control tanks and are placed in electric furnaces to simulate conditions in the kiln. The laboratory clinker is analyzed after 45 minutes in the furnace and from these data and similar data on the other control tanks the laboratory can control the blend to be taken from each tank. The theoretical analysis and the actual analysis of the kiln clinkers varies no more than 0.2%. Clinker samples are subjected to complete analysis every hour. The gypsum is analyzed for SO_3 content. A complete analysis is run on the 24-hour run of the finished product. Among the qualities not desired in cement are high magnesia and free lime because these compounds tend to disintegrate the cement by hydrating.

The physical laboratory runs the physical analyses. Samples are collected each hour of the raw material, the clinker, the coal, and the finished cement and analyzed for fineness. The cement must pass a 200-mesh and a 325-mesh screen test. A continuous sample is taken from the pump leading from the separators to the

bins and silos.

On the finished product tests are run on time of set with the use of the Gillmore needle. For initial set a quarter-pound needle must sink no more than 1/12 of an inch while at final set the pound needle must sink no more than 1/24 of an inch.

The cement is tested for tensile strength. It is made up with 20 to 30 mesh sand and placed in molds in a constant humidity box. After setting for 1, 3, 7, or 28 days, the tensile strength is tested on a standard machine.

For soundness, the cement is made up with water and kept at 70°F and 94 to 96% humidity for 24 hours. It is then subjected to steam for 15 minutes and inspected for soundness. The cement must be sound.

The compression test is run on cement made up with a 2.77 mix with C-107T34 sand. The cement is molded as a cube and allowed to set. It is then subjected to a standard compression test.

The autoclave test measures the expansion of the cement. The cement is molded in bar form and its length calibrated with a meter. The bar is then subjected to 300 pounds steam pressure for three hours. It then cools for 15 minutes by placing in water at 80°F. Then it is regaged. The difference in readings is the percent expansion, the maximum limit of which is 0.5%.

The tests run at Security are all analytical and control. The research laboratory is situated in New York State.

Chemical control laboratory

VI CONCLUSION

The Security plant is very modern and efficient. Proud of its safety record, the plant has operated for over seven months without a lost-time accident.

The method employed to make cement is that known as the "Dry Process", used almost exclusively in the United States.

The industry is one of great importance to our country and to the world at large. With the industry as well organized as it is today, we need never lack that valuable product- Cement.

FINIS

BIBLIOGRAPHY

NORTH AMERICAN CEMENT CORPORATION

(1) Mr. Zaiser, general plant guide

(2) Mr. Samuelson, chemistry laboratory guide

(3) Mr. Eiler, physical laboratory guide

THE STORY OF CEMENT, published by North American Cement Corporation

Reigel, INDUSTRIAL CHEMISTRY

Leighou, CHEMISTRY OF ENGINEERING MATERIALS